MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1 , 2022/2023 (TERM ID 2210)

ERT3026 – AUTOMATION

(RE)

11 FEBRUARY 2023
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of **7 pages** including cover page and Appendix with **4 Questions** only.

2. Answer **ALL** questions. The distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Conveyor is one common device for industrial automation. Design a programmable logic controller (PLC) ladder diagram using **ONE timer** and **TWO counters** to perform the Bi-directional control of a conveyor system with the following conditions:

- Turn on the input switch to start the Bi-directional control of conveyor system.
- Perform the Bi-directional control of conveyor when three square boxes are counted. Sensor is used to detect the number of boxes.

Use the input and output assignment as shown in Table Q1(a).

[17 marks]

Table Q1(a). The Input/Output Assignment for Question 1(a)

Devices	**Input Address**
Start Switch (SW1)	0.00
Reset Switch (SW2)	0.01
Sensor (SE1)	0.02
Devices	**Output Address**
Conveyor moves in forward direction	2.00
Conveyor moves in backward direction	2.01

(b) Construct the ladder logic diagrams for the NAND logic and NOR logic.

[8 marks]

Continued...

Question 2

(a) A proposed synchronous transfer line will have 20 stations and will operate with an ideal cycle time of 0.5 min. All stations are expected to have an equal probability of breakdown, $p = 0.01$. The average downtime per breakdown is expected to be 5.0 min. The cost to operate the line is \$96.00/hr. Ignoring material and tooling costs, determine **line efficiency**, **production rate**, and **unit cost** for this configuration.

[9 marks]

(b) A batch of parts is produced on a semiautomated production machine. Batch size is 250 units. Setup requires 50 min. A worker loads and unloads the machine each cycle, which takes 0.40 min. Machine processing time is 2.50 min/cycle, and tool handling time is negligible. One part is produced each cycle. Determine the **average cycle time**, **time to complete the batch** and **average production rate**.

[8 marks]

(c) Costs have been compiled for a certain manufacturing company for the most recent year. The summary is shown in the Table Q2(c). The company operates two different manufacturing plants, plus a corporate headquarters. The firm will use these rates in the following year.
Determine the **factory overhead rate** for each plant, and the **corporate overhead rate**.

Table Q2(c). Cost summary table for Question 2(c)

Expense category	Plant 1	Plant 2	Corporate headquarters
Direct labor	\$1,000,000	\$1,750,000	
Materials	\$3,500,000	\$4,000,000	
Factory expense	\$1,300,000	\$2,300,000	
Corporate expense			\$5,000,000

[8 marks]

Continued ...

Question 3

(a) In the general assembly department of an automobile final assembly plant, there are 500 workstations, and the cycle time = 0.98 min. If each workstation is 7.0 m long, and the tolerance time is equal to the cycle time.
Determine the following.

(i) Speed of the conveyor. **[2 marks]**

(ii) Center-to-Center spacing between the units on the line. **[2 marks]**

(iii) Total length of the general assembly line, assuming no vacant space between stations. **[2 marks]**

(iv) Elapsed time a work unit spends in the general assembly department. **[2 marks]**

(b) A plastic injection moulding plant will be built to produce 5,000,000 moulded parts/yr. The plant will run two 8-hr shifts per day, five days/wk, 52 wk/yr. For planning purposes, the average batch size = 10000 mouldings, average changeover time between batches = 3 hr, and average moulding cycle time per part = 18 sec. Assume scrap rate = 3%, and availability for each moulding machine = 100%, which applies to both run time and changeover time.

(i) How many moulding machines are required in the new plant? **[13 marks]**

(ii) What is the time required to produce each batch? **[4 marks]**

Continued ...

Question 4

A flexible manufacturing system (FMS) is used to produce four products (A, B, C, and D). The system consists of three processing stations (Vertical Milling, Horizontal Milling, Drilling) each with **1 server**, an Assembly station with **3 servers** and a load/unload station with **2 servers**. The product mix and station times for the parts are presented in the Table Q4.

Table Q4. The product mix and station times for Question 4

Product	Product mix	Station 1	Station 2	Station 3	Station 4	Station 5	Station 1
A	0.2	4 min	7 min	8 min	6 min	12 min	3 min
B	0.35	4 min	6 min	8 min	7 min	11 min	3 min
C	0.2	4 min	5 min	5 min	7 min	14 min	3 min
D	0.25	4 min	6min	6 min	10 min	18 min	3 min

The system also uses automated guided vehicles (AGVS) with **9 vehicles** to transport parts between servers. The vehicles deliver parts to the individual machines and then go perform other work.

All products follow the same routing, which is **1→ 2 → 3 → 4 → 5 → 1.** The operation frequency is 1.0 for all stations. The mean travel time of the AGVS between any two stations is 3 min which includes the time required to transfer loads to and from the stations.

Find **the overall production rate, manufacturing lead time**, and **waiting time** with the $N = 14$ ***parts*** in the system by using the extended bottleneck model.

[25 marks]

Continued ...

APPENDIX

TABLE 1: Useful Formulas

$R_p = \frac{1}{T_p}$	$T_p = \frac{T_b}{Q}$	$T_b = T_{su} + QT_c$	$T_c = \text{Max}\{T_m, T_s\} + T_r$	
$E = \frac{T_c}{T_p}$	$T_c \leq \frac{E}{R_p}$	$T_p = T_c + \sum_j F_j T_d$	$C_{pc} = C_L T_p + C_m + C_t$	
$D = \frac{FT_d}{T_p}$	$R_{dv} = \frac{AT}{T_c}$	$d = \frac{nT_s - T_{wc}}{nT_s}$	$T_C = T_L + \frac{L_d}{v_c} + T_U + \frac{L_e}{v_e}$	
$T_t = \frac{L_s}{v_c}$	$E_b = \frac{T_{wc}}{n\,T_s}$	$AT = S_w H_{sh} AU$	$WL = \frac{QT_c}{(1-q)E_w}$	
$T_c = \frac{s_p}{v_c}$	$f_p = \frac{v_c}{s_p}$	$AT = 60\,A\,T_f\,E$	$WL_{n+1} = n_t t_{n+1}$	
$s_c = v_c\,T_L$	$v_c = \frac{L_d}{T_d}$	$AT = H_p\,A\,U$	$T_{wc} = \sum_{j=1}^{n_e} T_{ej} = \sum_i^n T_{si}$	
$n = \frac{R_f}{R_{dv}}$	$n = \frac{WL}{AT}$	$WL = R_f\,T_c$	$WL_i = \sum_j \sum_k t_{ijk}\,f_{ijk}\,p_j$	
$ET = \frac{L}{v_c}$	$n = \frac{w}{M}$	$R_p^* = \frac{s^*}{WL^*}$	$n_t = \left(\sum_i \sum_j \sum_k f_{ijk}\,p_j\right) - 1$	
$F = \sum_i^n p_i$	$L = \sum_{i=1}^n L_{si}$	$F = 1 - \left[\prod_{i=1}^n (1-p_i)\right]$	$N^* = R_p^* \left(\sum_{i=1}^n WL_i + WL_{n+1}\right)$	
$R_p^* = \frac{s^*}{WL^*}$	$U_i = \frac{WL_i}{s_i}(R_p^*)$	$\overline{U} = \frac{\sum_{i=1}^{n+1} U_i}{n+1}$	$\overline{U_s} = \frac{\sum_{i=1}^n s_i U_i}{\sum_{i=1}^n s_i}$	
$ET = n\,T_t$	$R_{pj}^* = p_j(R_p^*)$	$BS_i = WL_i(R_p^*)$	$FOHR = \frac{FOHC}{DLC}$	$COHR = \frac{COHC}{DLC}$

Continued ...

TABLE 2: Extended Bottleneck Model

Case 1: N < N*	Case 2: N ≥N*
$MLT_1 = \sum_{i=1}^{n} WL_i + WL_{n+1}$	$R_p^* = \frac{s^*}{WL^*}$
$R_p = \frac{N}{MLT_1}$	$R_{pj}^* = p_j(R_p^*)$
$R_{pj} = p_j R_p$	$MLT_2 = \frac{N}{R_p^*}$
$T_w = 0$	$T_w = MLT_2 - \sum_{i=1}^{n} WL_i + WL_{n+1}$

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